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(54) **SYSTEMS AND METHODS FOR ANALYZING OPERATIONS IN A MULTI-TENANT DATABASE SYSTEM ENVIRONMENT**

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G06F 11/36 (2006.01)
G06F 7/00 (2006.01)

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CPC ***G06F 11/3636*** (2013.01); ***G06F 17/30371*** (2013.01); ***G06F 17/3051*** (2013.01)

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(56) **References Cited**

U.S. PATENT DOCUMENTS

5,577,188	A	11/1996	Zhu
5,608,872	A	3/1997	Schwartz et al.
5,649,104	A	7/1997	Carleton et al.
5,715,450	A	2/1998	Ambrose et al.
5,761,419	A	6/1998	Schwartz et al.
5,819,038	A	10/1998	Carleton et al.
5,821,937	A	10/1998	Tonelli et al.
5,831,610	A	11/1998	Tonelli et al.
5,873,096	A	2/1999	Lim et al.
5,918,159	A	6/1999	Fomukong et al.
5,963,953	A	10/1999	Cram et al.
6,092,083	A	7/2000	Brodersen et al.
6,169,534	B1	1/2001	Raffel et al.

(Continued)

OTHER PUBLICATIONS

Salesforce.com, "The Force.com Multitenant Architecture, Understanding the Design of Salesforce.com's Internet Application Development Platform," Whitepaper, 2008, pp. 1-16.*

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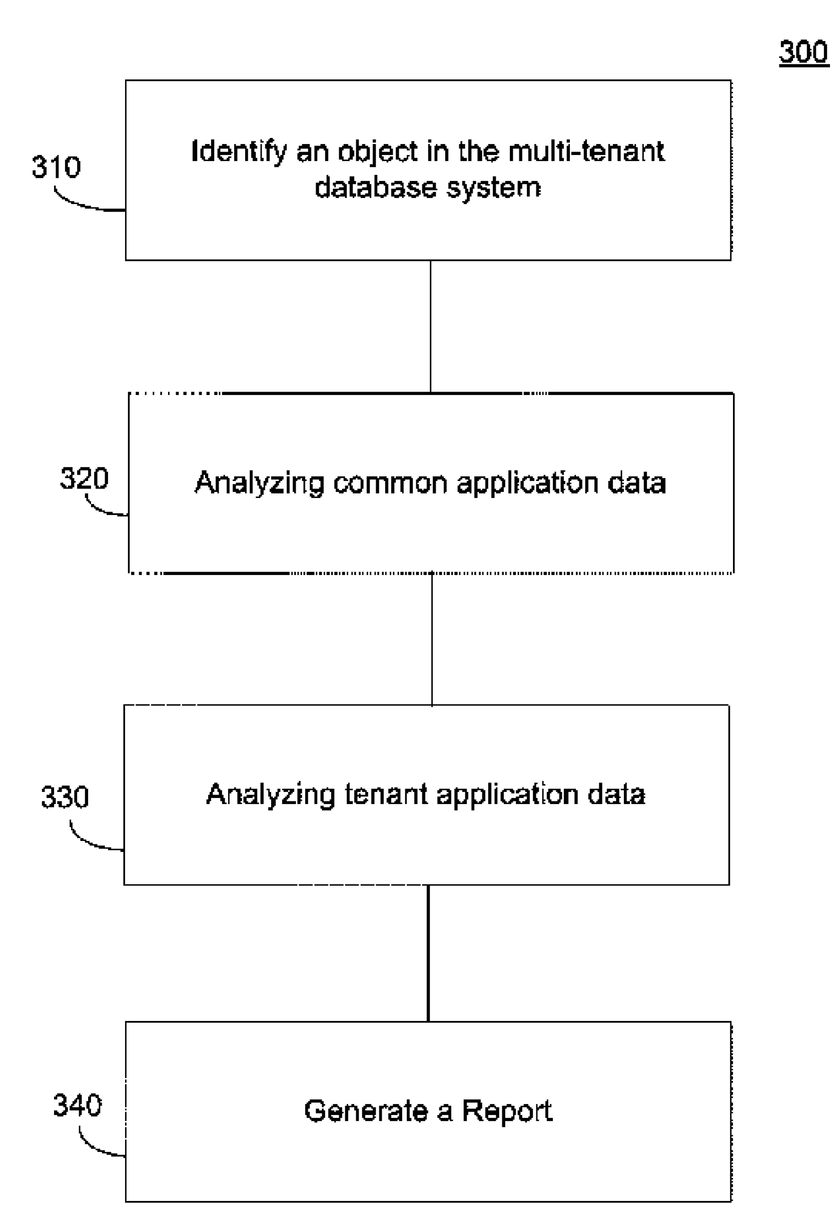
(57) **ABSTRACT**

A system and method for analyzing operations in a multi-tenant database system environment is provided. The system may include a database storing tenant application data and common application data, the tenant application data and common application data controlling a creation, read, update, deletion or undeletion of an object in the multi-tenant database system environment. The system may further include a processor to analyze the tenant application data and common application data to identify therein where the object is being modified, and generate a report identifying potential errors or side effects which may affect the object based upon the analyzed tenant application data and common application data.

20 Claims, 4 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

6,178,425	B1	1/2001	Brodersen et al.	
6,189,011	B1	2/2001	Lim et al.	
6,216,135	B1	4/2001	Brodersen et al.	
6,233,617	B1	5/2001	Rothwein et al.	
6,266,669	B1	7/2001	Brodersen et al.	
6,295,530	B1	9/2001	Ritchie et al.	
6,324,568	B1	11/2001	Diec et al.	
6,324,693	B1	11/2001	Brodersen et al.	
6,336,137	B1	1/2002	Lee et al.	
D454,139	S	3/2002	Feldcamp et al.	
6,367,077	B1	4/2002	Brodersen et al.	
6,393,605	B1	5/2002	Loomans	
6,405,220	B1	6/2002	Brodersen et al.	
6,434,550	B1	8/2002	Warner et al.	
6,446,089	B1	9/2002	Brodersen et al.	
6,535,868	B1 *	3/2003	Galeazzi et al.	1/1
6,535,909	B1	3/2003	Rust	
6,539,396	B1 *	3/2003	Bowman-Amuah	707/769
6,549,908	B1	4/2003	Loomans	
6,553,563	B2	4/2003	Ambrose et al.	
6,560,461	B1	5/2003	Fomukong et al.	
6,574,635	B2	6/2003	Stauber et al.	
6,577,726	B1	6/2003	Huang et al.	
6,601,087	B1	7/2003	Zhu et al.	
6,604,117	B2	8/2003	Lim et al.	
6,604,128	B2	8/2003	Diec	
6,609,150	B2	8/2003	Lee et al.	
6,621,834	B1	9/2003	Scherpbier et al.	
6,654,032	B1	11/2003	Zhu et al.	
6,665,648	B2	12/2003	Brodersen et al.	
6,665,655	B1	12/2003	Warner et al.	
6,684,438	B2	2/2004	Brodersen et al.	
6,711,565	B1	3/2004	Subramaniam et al.	
6,724,399	B1	4/2004	Katchour et al.	
6,728,702	B1	4/2004	Subramaniam et al.	
6,728,960	B1	4/2004	Loomans et al.	
6,732,095	B1	5/2004	Warshavsky et al.	
6,732,100	B1	5/2004	Brodersen et al.	
6,732,111	B2	5/2004	Brodersen et al.	
6,754,681	B2	6/2004	Brodersen et al.	
6,763,351	B1	7/2004	Subramaniam et al.	
6,763,501	B1	7/2004	Zhu et al.	
6,768,904	B2	7/2004	Kim	
6,782,383	B2	8/2004	Subramaniam et al.	
6,799,184	B2 *	9/2004	Bhatt et al.	707/718
6,804,330	B1	10/2004	Jones et al.	
6,826,565	B2	11/2004	Ritchie et al.	
6,826,582	B1	11/2004	Chatterjee et al.	
6,826,745	B2	11/2004	Coker	
6,829,655	B1	12/2004	Huang et al.	
6,842,748	B1	1/2005	Warner et al.	
6,850,895	B2	2/2005	Brodersen et al.	
6,850,949	B2	2/2005	Warner et al.	
7,127,461	B1 *	10/2006	Zhu et al.	707/694
7,149,728	B1 *	12/2006	Feinberg et al.	1/1
7,340,411	B2	3/2008	Cook	
7,620,655	B2	11/2009	Larsson et al.	
7,698,160	B2	4/2010	Beaven et al.	
7,788,228	B2 *	8/2010	Feinberg et al.	707/640
8,082,301	B2	12/2011	Ahlgren et al.	
8,095,413	B1	1/2012	Beaven	
8,095,594	B2	1/2012	Beaven et al.	
8,275,836	B2	9/2012	Beaven et al.	
8,797,178	B2 *	8/2014	Kansal et al.	340/870.07
2001/0044791	A1	11/2001	Richter et al.	
2002/0072951	A1	6/2002	Lee et al.	
2002/0082892	A1	6/2002	Raffel	
2002/0129352	A1	9/2002	Brodersen et al.	
2002/0140731	A1	10/2002	Subramanian et al.	
2002/0143997	A1	10/2002	Huang et al.	
2002/0162090	A1	10/2002	Parnell et al.	
2002/0165742	A1	11/2002	Robbins	
2003/0004971	A1	1/2003	Gong	
2003/0018705	A1	1/2003	Chen et al.	
2003/0018830	A1	1/2003	Chen et al.	
2003/0066031	A1	4/2003	Laane et al.	
2003/0066032	A1	4/2003	Ramachandran et al.	
2003/0069936	A1	4/2003	Warner et al.	
2003/0070000	A1	4/2003	Coker et al.	
2003/0070004	A1	4/2003	Mukundan et al.	
2003/0070005	A1	4/2003	Mukundan et al.	
2003/0074418	A1	4/2003	Coker et al.	
2003/0120675	A1	6/2003	Stauber et al.	
2003/0151633	A1	8/2003	George et al.	
2003/0159136	A1	8/2003	Huang et al.	
2003/0187921	A1	10/2003	Diec et al.	
2003/0189600	A1	10/2003	Gune et al.	
2003/0204427	A1	10/2003	Gune et al.	
2003/0206192	A1	11/2003	Chen et al.	
2003/0225730	A1	12/2003	Warner et al.	
2003/0233404	A1	12/2003	Hopkins	
2004/0001092	A1	1/2004	Rothwein et al.	
2004/0010489	A1	1/2004	Rio et al.	
2004/0015981	A1	1/2004	Coker et al.	
2004/0027388	A1	2/2004	Berg et al.	
2004/0128001	A1	7/2004	Levin et al.	
2004/0181560	A1 *	9/2004	Romanufa et al.	707/202
2004/0186860	A1	9/2004	Lee et al.	
2004/0193510	A1	9/2004	Catahan et al.	
2004/0199489	A1	10/2004	Barnes-Leon et al.	
2004/0199536	A1	10/2004	Barnes Leon et al.	
2004/0199543	A1	10/2004	Braud et al.	
2004/0210909	A1	10/2004	Dominquez, Jr. et al.	
2004/0249854	A1	12/2004	Barnes-Leon et al.	
2004/0260534	A1	12/2004	Pak et al.	
2004/0260659	A1	12/2004	Chan et al.	
2004/0268299	A1	12/2004	Lei et al.	
2005/0039033	A1 *	2/2005	Meyers et al.	713/193
2005/0050555	A1	3/2005	Exley et al.	
2005/0065925	A1	3/2005	Weissman et al.	
2005/0091098	A1	4/2005	Brodersen et al.	
2005/0223022	A1	10/2005	Weissman et al.	
2005/0283478	A1	12/2005	Choi et al.	
2006/0206834	A1	9/2006	Fisher et al.	
2006/0235714	A1 *	10/2006	Adinolfi et al.	705/1
2006/0235715	A1 *	10/2006	Abrams et al.	705/1
2008/0162491	A1 *	7/2008	Becker et al.	707/10
2008/0243867	A1 *	10/2008	Janedittakarn et al.	707/10
2009/0282045	A1 *	11/2009	Hsieh et al.	707/9
2010/0106752	A1 *	4/2010	Eckardt et al.	707/805
2010/0162231	A1 *	6/2010	Lanchares et al.	717/177
2010/0306249	A1 *	12/2010	Hill et al.	707/769
2011/0252009	A1 *	10/2011	Simons et al.	707/694

* cited by examiner

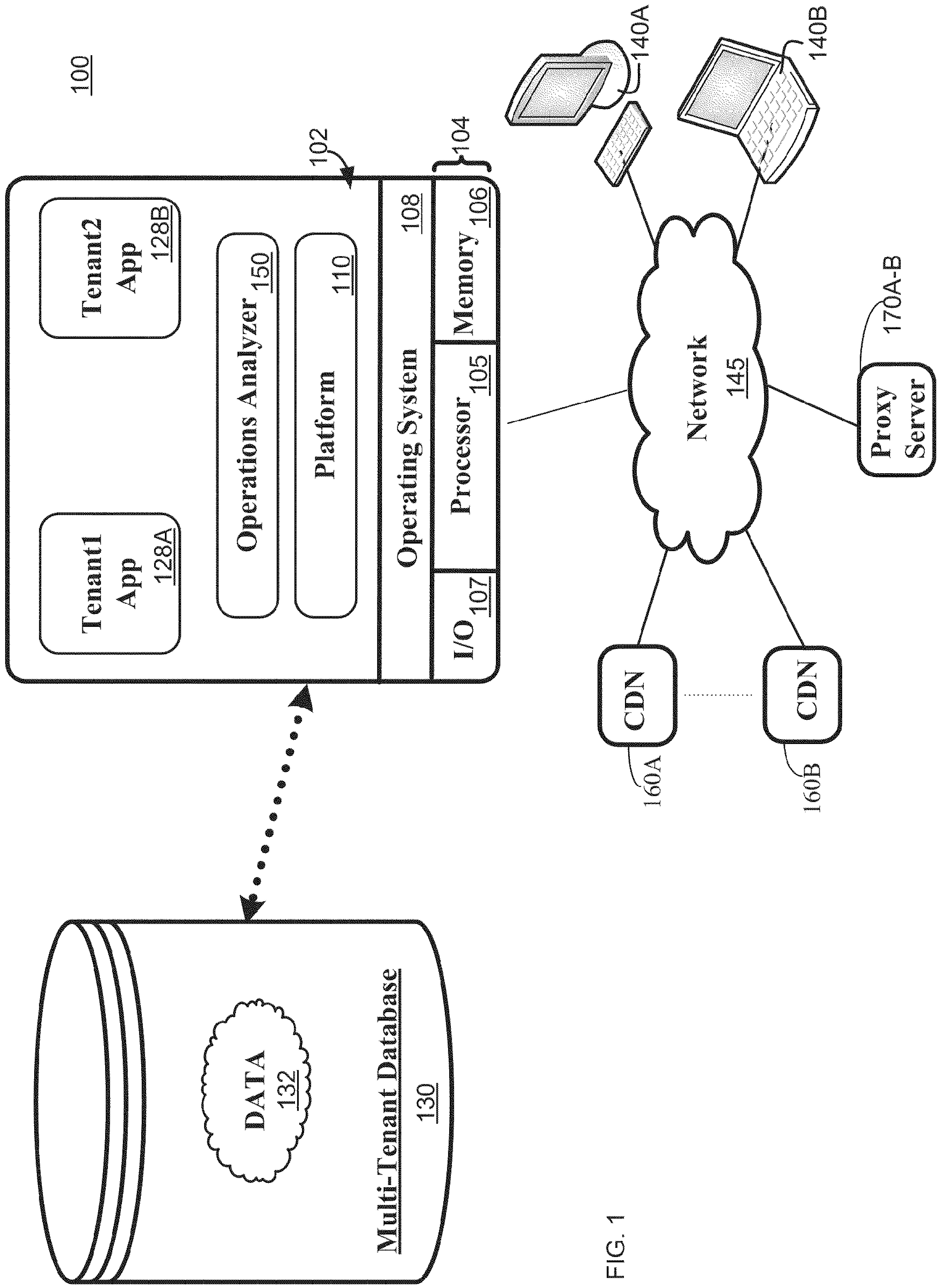

100
102
Tenant2 App 128B
Tenant1 App 128A
Operations Analyzer 150
Platform 110
Operating System 108
104
Memory 106
Processor 105
I/O 107
140A
140B
Network 145
170A-B
Proxy Server
CDN
CDN
160A
160B
DATA 132
Multi-Tenant Database 130

FIG. 1

FIG. 2

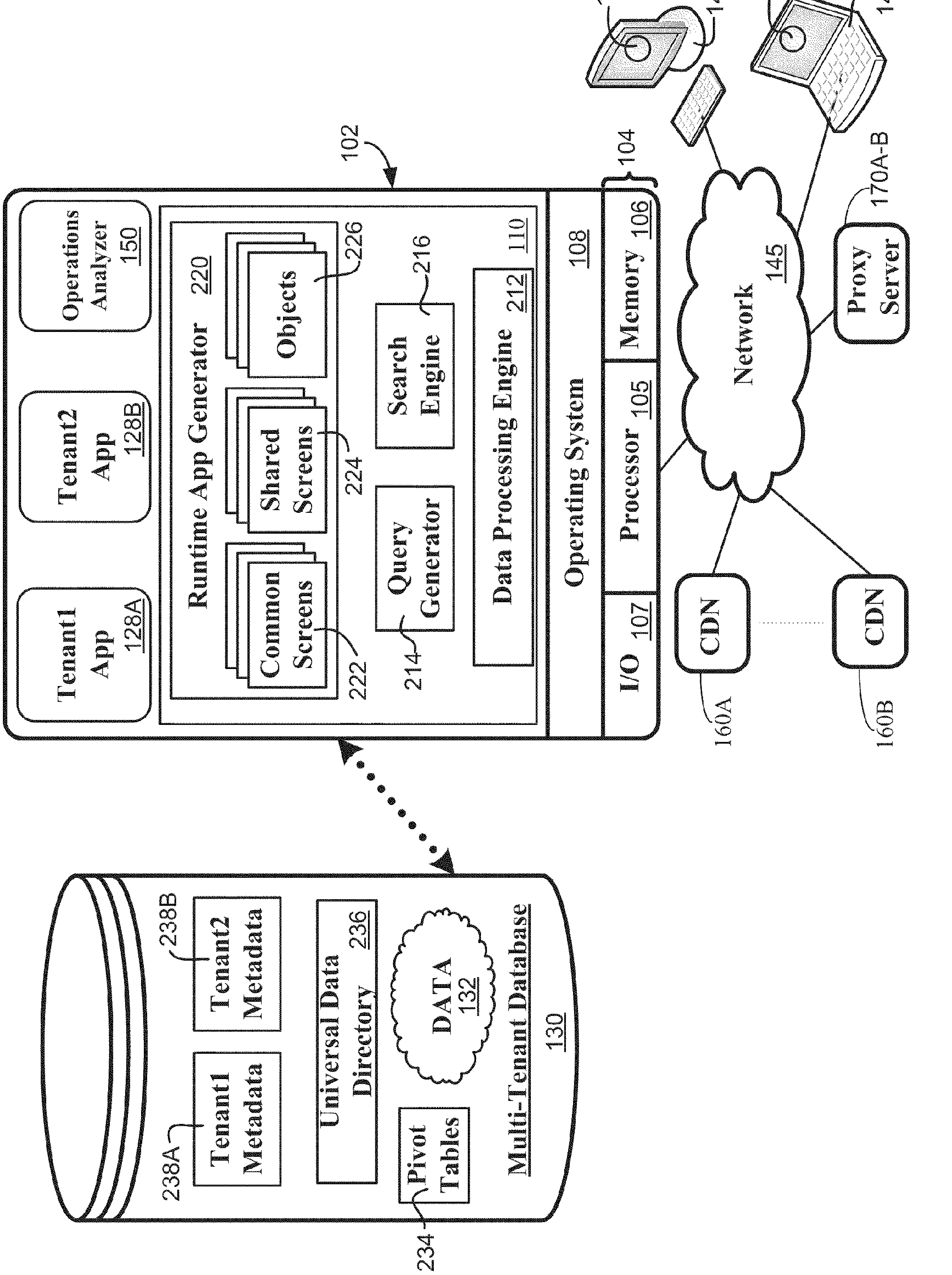

200
102
Tenant1 App 128A
Tenant2 App 128B
Operations Analyzer 150
Runtime App Generator 220
Common Screens
222
Shared Screens
224
Objects
226
Query Generator
214
Search Engine
216
Data Processing Engine 212
110
Operating System 108
I/O 107
Processor 105
Memory 106
104
Network 145
CDN
160A
CDN
160B
Proxy Server
170A-B
142A
140A
142B
140B
Tenant1 Metadata
238A
Tenant2 Metadata
238B
Universal Data Directory 236
DATA 132
Pivot Tables
234
Multi-Tenant Database 130

FIG. 3

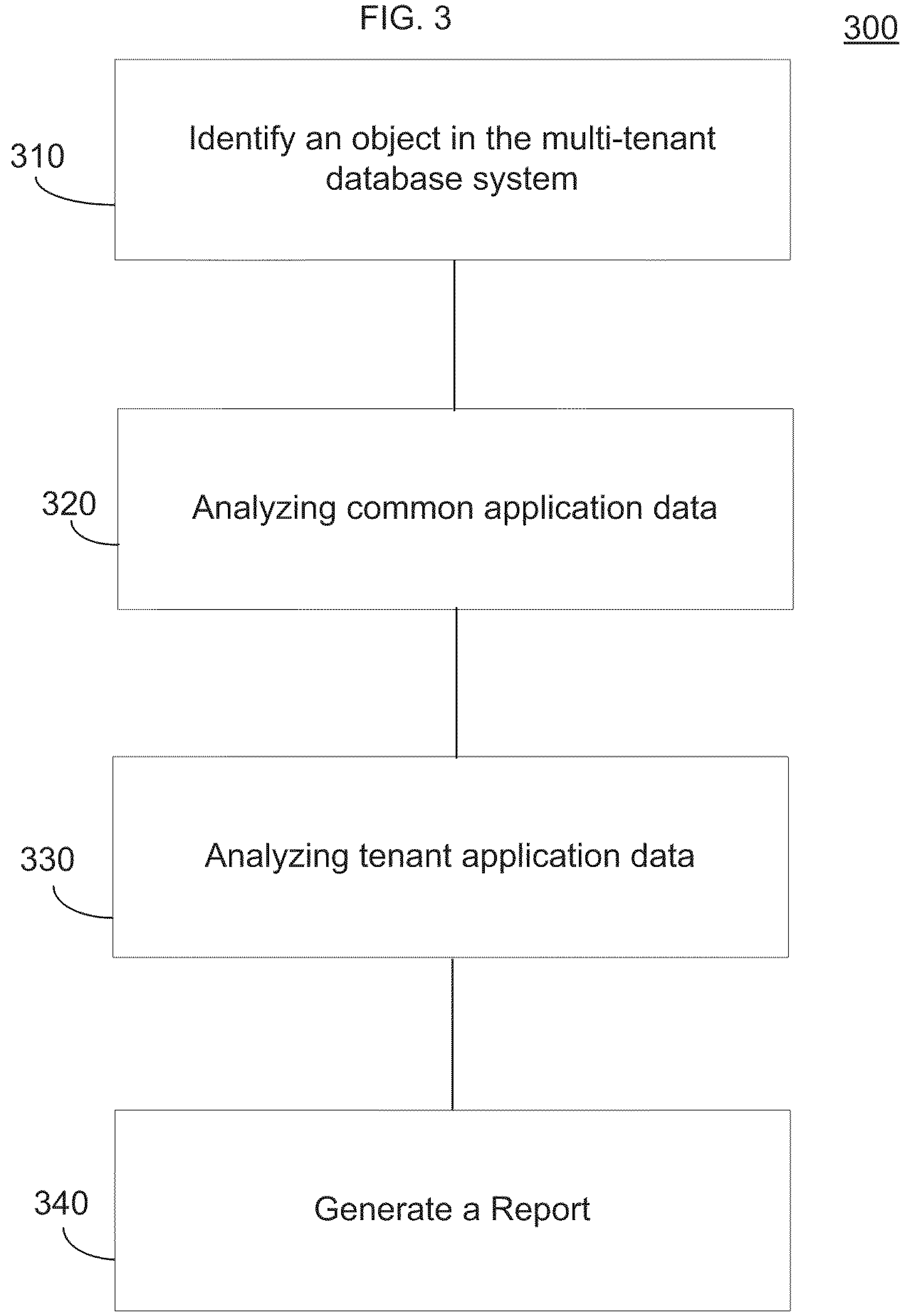
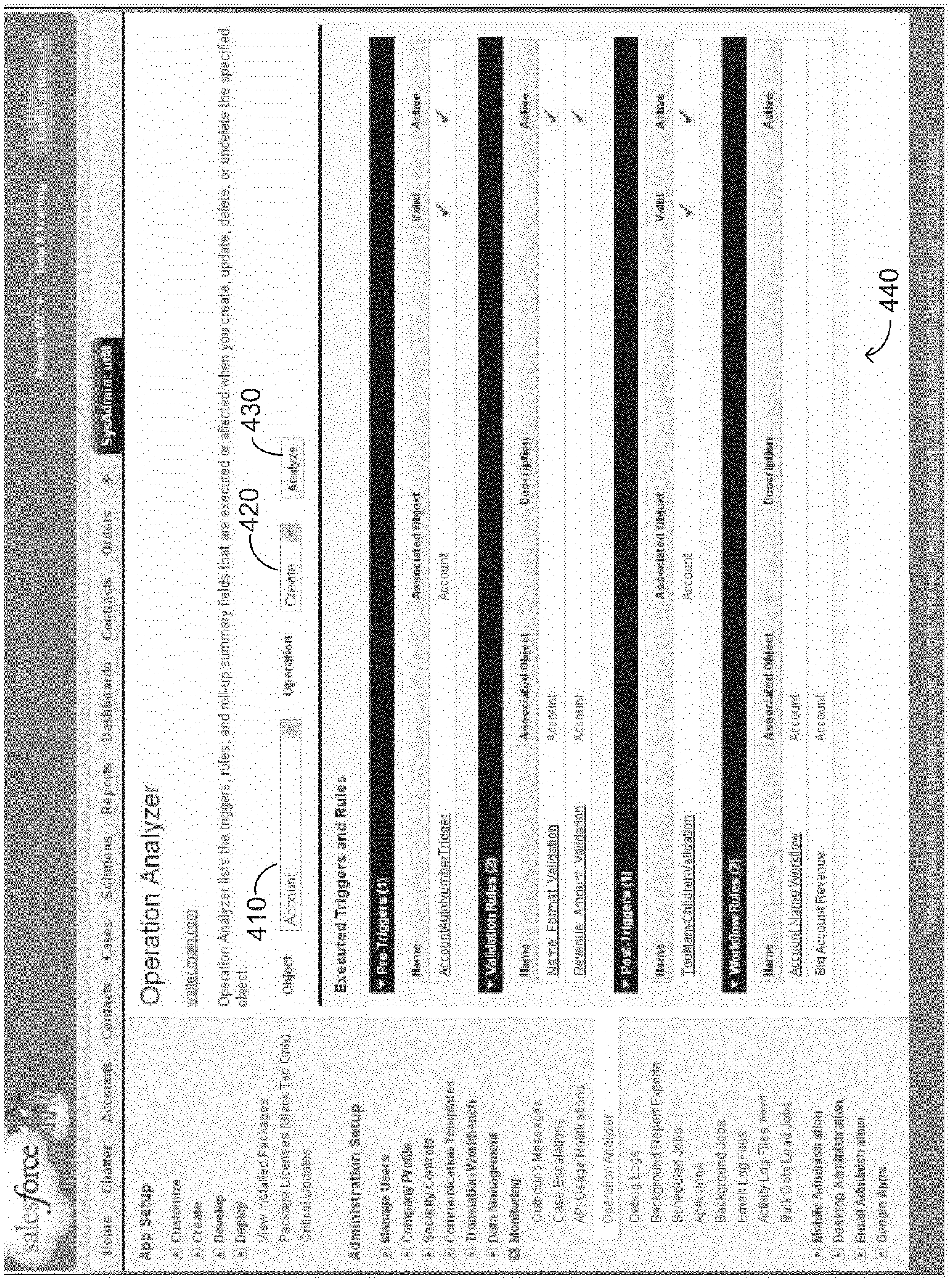

300
310
Identify an object in the multi-tenant database system
320
Analyzing common application data
330
Analyzing tenant application data
340
Generate a Report

FIG. 4

400



Home Chatter Accounts Contacts Cases Solutions Reports Dashboards Contracts Orders
SysAdmin: ut8
Admin BA1
Help & Training
Call Center
App Setup
Customize
Create
Develop
Deploy
View Installed Packages
Package Licenses (Black Tab Only)
Critical Updates
Administration Setup
Manage Users
Company Profile
Security Controls
Communication Templates
Translation Workbench
Data Management
Monitoring
Outbound Messages
Case Escalations
API Usage Notifications
Operation Analyzer
Debug Logs
Background Report Exports
Scheduled Jobs
Apex Jobs
Background Jobs
Email Log Files
Activity Log Files
Bulk Data Load Jobs
Mobile Administration
Desktop Administration
Email Administration
Google Apps
Operation Analyzer
Operation Analyzer lists the triggers, rules, and roll-up summary fields that are executed or affected when you create, update, delete, or undelete the specified object.
Object
Account
410
Operation
Create
420
Analyze
430
Executed Triggers and Rules
Pre-Triggers (1)
Name
Associated Object
Valid
Active
AccountAutoNumberTrigger
Account
Validation Rules (2)
Description
Name_Format_Validation
Revenue_Amount_Validation
Post-Triggers (1)
TooManyChildrenValidation
Workflow Rules (2)
Account Name Workflow
Big Account Revenue
440

SYSTEMS AND METHODS FOR ANALYZING OPERATIONS IN A MULTI-TENANT DATABASE SYSTEM ENVIRONMENT

CROSS-REFERENCE TO RELATED APPLICATION(S)

This application claims the benefit of U.S. provisional patent application Ser. No. 61/352,280, filed Jun. 7, 2010, the entire content of which is incorporated by reference herein.

TECHNICAL FIELD

The following relates to data processing systems and processes, and more particularly relates to systems and processes for analyzing operations in a multi-tenant database system environment.

BACKGROUND

Modern software development is evolving away from the client-server model toward "cloud"-based processing systems that provide access to data and services via the Internet or other networks. In contrast to prior systems that hosted networked applications on dedicated server hardware, the cloud computing model allows applications to be provided over the network "as a service" supplied by an infrastructure provider. The infrastructure provider typically abstracts the underlying hardware and other resources used to deliver a customer-developed application so that the customer no longer needs to operate and support dedicated server hardware. The cloud computing model can often provide substantial cost savings to the customer over the life of the application because the customer no longer needs to provide dedicated network infrastructure, electrical and temperature controls, physical security and other logistics in support of dedicated server hardware.

Although multi-tenant platforms can provide substantial benefits, they can be relatively difficult to design and develop. The often competing demands of integration and isolation between tenants, for example, can lead to any number of challenges in design and implementation. For example, while each tenant writes their own application code for their respective customer-developed application, the "cloud"-based processing system also contains application code which is universal to all of the tenants. Accordingly, it can be difficult at times to de-bug errors or determine a cause of a side-effect affecting a customer-developed application.

DESCRIPTION OF THE DRAWING FIGURES

Exemplary embodiments will hereinafter be described in conjunction with the following drawing figures, wherein like numerals denote like elements, and

FIG. **1** is a block diagram of an exemplary multi-tenant data processing system;

FIG. **2** is a block diagram of another exemplary multi-tenant data processing system;

FIG. **3** is a flow chart illustrating an exemplary method of performing an operations analysis within the multi-tenant data processing system; and

FIG. **4** is an exemplary user interface for performing an operations analysis within the multi-tenant data processing system.

DETAILED DESCRIPTION

According to various exemplary embodiments, systems and methods are provided to analyze operations in a multi-tenant database system environment.

Turning now to FIG. **1**, an exemplary multi-tenant application system **100** suitably includes a server **102** that dynamically creates virtual applications **128**A-B based upon data **132** from a common database **130** that is shared between multiple tenants. Data and services generated by the virtual applications **128**A-B are provided via network **145** to any number of client devices **140**A-B, as desired. Each virtual application **128**A-B is suitably generated at run-time using a common platform **110** that securely provides access to data **132** in database **130** for each of the various tenants subscribing to system **100**. The multi-tenant application system **100** may also include any number of content delivery networks ("CDNs") **160**A-B, as desired. The CDNs **160**A-B may contain a copy of at least some of the data **132** which may be accessible via the network **145**. The multi-tenant application system **100** may also employ any number of proxy servers **170**A-B which may be used to direct traffic between the server **102** and the CDNs **160**A-B.

A "tenant" generally refers to a group of users that shares access to common data within database **130**. Tenants may represent customers, customer departments, business or legal organizations, and/or any other entities that maintain data for particular sets of users within system **100**. Although multiple tenants may share access to a common server **102** and database **130**, the particular data and services provided from server **102** to each tenant can be securely isolated from those provided to other tenants, as described more fully below. However, the applications **128**A-B, which are generally written by the customer, may also share common application data in the database **130**. The multi-tenant architecture allows different sets of users to share functionality without necessarily sharing each other's data **132**.

Database **130** is any sort of repository or other data storage system capable of storing and managing data **132** associated with any number of tenants. Database **130** may be implemented using conventional database server hardware. In various embodiments, database **130** shares processing hardware **104** with server **102**. In other embodiments, database **130** is implemented using separate physical and/or virtual database server hardware that communicates with server **102** to perform the various functions described herein.

Server **102** is implemented using one or more actual and/or virtual computing systems that collectively provide a dynamic application platform **110** for generating virtual applications **128**A-B. Server **102** operates conventional computing hardware **104**, such as a processor **105**, memory **106**, input/output features **107** and the like. Processor **105** may be implemented using one or more of microprocessors, microcontrollers, processing cores and/or other computing resources spread across any number of distributed or integrated systems, including any number of "cloud-based" or other virtual systems. Memory **106** represents any non-transitory short or long term storage capable of storing programming instructions for execution on processor **105**, including any sort of random access memory (RAM), read only memory (ROM), flash memory, magnetic or optical mass storage, and/or the like. Input/output features **107** represent conventional interfaces to networks (e.g., to network **145**, or any other local area, wide area or other network), mass storage, display devices, data entry devices and/or the like. In a typical embodiment, application platform **110** gains access to processing resources, communications interfaces and other features of hardware **104** using any sort of conventional or proprietary operating system **108**. As noted above, server **102** may be implemented using a cluster of actual and/or virtual servers operating in conjunction with each other, typically in association with conventional network communications, cluster management, load balancing and other features as appropriate.

The server **102** also includes an operations analyzer **150**. The operations analyzer **150** analyzes objects that users may interact with in the multi-tenant database system **100** through client devices **140**A-B. The objects may be, for example, one or more of the following: an account, an opportunity and a lead. User's of the system may also define custom objects that are specific to their own application. Each of the objects may have one or more data fields. Each instance of an object may be called a record. Further, each object may be represented by a table. The objects may be interacted with by a user, for example, by creating the object, reading the object, updating an existing object and deleting or undeleting an object. These operations may be referred to as "CRUD" operations (Create, Read, Update, Delete/undelete). The operations analyzer **150** generates a report detailing what is affecting the object in the system **100**, as discussed in further detail below. In another embodiment the operations analyzer may be operable on the client devices **140**A-B or on another server (not illustrated).

FIG. **2** illustrates another exemplary multi-tenant application system **200** in accordance with an embodiment. The multi-tenant application system **200** includes client devices **140**A-B, network **145**, CDNs **160**A-B and proxy servers **170**A-B similar to those described above. The multi-tenant application system **200** further includes a server **102** that dynamically creates virtual applications **128**A-B based upon data **132** from a common database **130** that is shared between multiple tenants. Data and services generated by the virtual applications **128**A-B are provided via network **145** to any number of client devices **140**A-B, as desired. Each virtual application **128**A-B is suitably generated at run-time using a common platform **110** that securely provides access to data **132** in database **130** for each of the various tenants subscribing to system **100**.

Data **132** may be organized and formatted in any manner to support multi-tenant application platform **110**. In various embodiments, data **132** is suitably organized into a relatively small number of large data tables to maintain a semi-amorphous "heap"-type format. Data **132** can then be organized as needed for a particular virtual application **128**A-B. In various embodiments, conventional data relationships are established using any number of pivot tables **234** that establish indexing, uniqueness, relationships between entities, and/or other aspects of conventional database organization as desired.

Further data manipulation and report formatting is generally performed at run-time using a variety of meta-data constructs. Metadata within a universal data directory (UDD) **236**, for example, can be used to describe any number of forms, reports, workflows, user access privileges, business logic and other constructs that are common to multiple tenants. Tenant-specific formatting, functions and other constructs may be maintained as tenant-specific metadata **238**A-B for each tenant, as desired. Rather than forcing data **132** into an inflexible global structure that is common to all tenants and applications, then, database **130** is organized to be relatively amorphous, with tables **234** and metadata **236-238** providing additional structure on an as-needed basis. To that end, application platform **110** suitably uses tables **234** and/or metadata **236**, **238** to generate "virtual" components of applications **128**A-B to logically obtain, process, and present the relatively amorphous data **132** from database **130**.

Application platform **110** is any sort of software application or other data processing engine that generates virtual applications **128**A-B that provide data and/or services to client devices **140**A-B. Virtual applications **128**A-B are typically generated at run-time in response to queries received from client devices **140**A-B. In the example illustrated in FIG. **2**, application platform **110** includes a bulk data processing engine **212**, a query generator **214**, a search engine **216** that provides text indexing and other search functionality, and a runtime application generator **220**. Each of these features may be implemented as a separate process or other module, and many equivalent embodiments could include different and/or additional features, components or other modules as desired.

Runtime application generator **220** dynamically builds and executes virtual applications **128**A-B in response to specific requests received from client devices **140**A-B. Virtual applications **128**A-B created by tenants are typically constructed in accordance with tenant-specific metadata **238**, which describes the particular tables, reports, interfaces and/or other features of the particular application. In various embodiments, each virtual application **128**A-B generates dynamic web content that can be served to a browser or other client program **142**A-B associated with client device **140**A-B, as appropriate.

Application generator **220** suitably interacts with query generator **214** to efficiently obtain multi-tenant data **132** from database **130** as needed. In a typical embodiment, query generator **214** considers the identity of the user requesting a particular function, and then builds and executes queries to database **130** using system-wide metadata **236**, tenant specific metadata **238**, pivot tables **234** and/or any other available resources. Query generator **214** in this example therefore maintains security of the multi-tenant database **130** by ensuring that queries are consistent with access privileges granted to the user that initiated the request.

Data processing engine **212** performs bulk processing operations on data **132** such as uploads or downloads, updates, online transaction processing and/or the like. In many embodiments, less urgent bulk processing of data **132** can be scheduled to occur as processing resources become available, thereby giving priority to more urgent data processing by query generator **214**, search engine **216**, virtual applications **128**A-B and/or the like. Again, the various components, modules and inter-relationships of other application platforms **120** may vary from the particular examples described herein.

In operation, then, developers use application platform **110** to create data-driven virtual applications **128**A-B for the tenants that they support. Such applications **128**A-B may make use of interface features such as tenant-specific screens **224**, universal screens **222** or the like. Any number of tenant-specific and/or universal objects **226** may also be available for integration into tenant-developed applications **128**A-B. Data **132** associated with each application **128**A-B is provided to database **130**, as appropriate, and stored until requested, along with metadata **138** that describes the particular features (e.g., reports, tables, functions, etc.) of tenant-specific application **128**A-B until needed.

Data and services provided by server **102** can be retrieved using any sort of personal computer, mobile telephone, tablet or other network-enabled client device **140** on network **145**. Typically, the user operates a conventional browser or other client program **242** to contact server **102** via network **145** using, for example, the hypertext transport protocol (HTTP) or the like. The user typically authenticates his or her identity to the server **102** to obtain a session identification ("SessionID") that identifies the user in subsequent communications with server **102**. When the identified user requests access to a virtual application **128**A-B, application generator **220** suitably creates the application at run time based upon metadata **236** and **238**, as appropriate. Query generator **214** suitably obtains the requested data **132** from database **130** as needed to populate the tables, reports or other features of virtual application **128**A-B. As noted above, the virtual application **128**A-B may contain Java, ActiveX or other content that can be presented using conventional client software **142**A-B running on client device **140**A-B; other embodiments may simply provide dynamic web or other content that can be presented and viewed by the user, as desired.

As discussed above, the server **102** includes an operations analyzer **150** which analyzes what affects an object in the system **100** and generates a report thereon. Each object, depending upon the CRUD operation being performed thereon, may be affected by multiple layers of the multi-tenant database system **100**. Accordingly, when an error occurs during one of the CRUD operations, it can be difficult to identify the problem. Furthermore, when CRUD operations occur on the object various side-effects can occur which may be difficult to trace. Accordingly, the multi-tenant system **150** utilizes operations analyzer **150** to identify where within the multi-tenant database system **100** the object is affected.

For example, the operations analyzer **150** may evaluate customer written code that affects an object before the object is saved (i.e., pre-trigger) to the database **130**. The code may be written by a customer, for example, in the Apex® programming language. The customer written code may, for example, validate the object, manipulate the object in some way or cancel the save operation. The customer written code may also make call-outs to other objects to be updated or deleted based upon pre-trigger customer written rules associated with a first object.

The operations analyzer **150** may also analyze system and custom validation rules or formula relating to the object before the object can be saved. System validation rules are rules that are universal to all of the tenants in the multi-tenant database system **100**. In contrast, custom validation rules and formula are written by each tenant. An example of a system rule is that an end date for an action associated with an object can not be before a start date, or that a name associated with an object cannot be null. The validation rules or formula may also be based upon a status of an object. For example, the status may be "New," "Open," or "Closed." However, any status may be associated with each object. A rule based upon a status may be, for example, a status dependent validation rule which, for example, may require an opportunity (i.e., the object) to have a signed contract before the opportunity can be closed. Another status dependent action, for example, is that an object may not be able to be opened until an invoicing address has been provided.

The operations analyzer **150** can also evaluate dependent lookups or foreign key links where a first object may be dependent upon a second object before the first object can be saved. For example, if a user is attempting to add a line item (i.e., the first object) to an opportunity (i.e., the second object) the operations analyzer may evaluate a status of the opportunity. For example, the addition of the line item to the opportunity may depend upon whether the opportunity is an open opportunity.

The operations analyzer **150** also evaluates various assignment, workflow, escalation and system rules as in further detail below. These rules may cause an action to occur based upon data associated of the object after the object is saved. For example, a data field associated with the object may trigger an email message to be sent. The operations analyzer **150** evaluates the object to determine which rules are affecting the object. Accordingly, if an unexpected action is triggered, or if a user believed an action should have been triggered, the operations analyzer **150** can generate a report illustrating all of the various rules which are affecting the object so that the user can easily trace the source of the error.

As discussed above, the operations analyzer **150** may evaluate assignment rules. For example, if the object is a record of a sales opportunity the object may be assigned to a different sales representative depending upon a state of a field associated with the object. For example, the object may be assigned to different users based upon a geographical location or monetary value associated with the sales opportunity.

Workflow rules, similar to the assignment rules, may cause an object to be modified based upon a state of the object or a data field associated with the object. For example, after the object is saved, the workflow rules may look at a state or data field associated with the object, and based upon the state or data field trigger an update of the same state or data field or another state or data field associated with the present object or another object. Workflow rules may also trigger an action. For example, after the object is saved, the workflow rules may trigger an email, create an object within the system **100** or some other action based upon a state of the object or a data field associated with the object.

The operations analyzer **150** may also evaluate escalation rules associated with an object. For example, an object may have a deadline associated with it. The escalation rule may trigger email reminders as the deadline approaches. In another embodiment, if a condition is met a message may be sent to a superior. For example, if the user does not meet the deadline associated with an object a message may be sent to a manager of the user.

The operations analyzer **150** can also evaluate system defined rules which may be associated with an object. The system defined rules may be rules universal to all of the tenants of the multi-tenant database system **100**. For example, the system rules may determine that a entered zip ode is in a proper format, that a billing zip code is in the billing state or that the state or country code is valid.

For each of the pre and post trigger events (i.e., pre save and post save), the operations analyzer **150** can also determine an amount of time or processing power used to perform the actions and generate a report thereon. Accordingly, the operations analyzer **150** can analyze the performance or efficiency of the CRUD operations.

In some instances the CRUD operations may trigger a recursive operation on an object. For example, a post-trigger rule may cause a field associated with an object to be updated. The updated field may cause another pre-trigger rule or a post-trigger rule, or multiple rules. Accordingly, in one embodiment, the operations analyzer **150** will also report when a recursive save of an identified object may occur and note which other objects may trigger a recursive save of the identified object.

FIG. **3** is a flow chart illustrating an exemplary operation of the operations analyzer **150**. The operations analyzer **150** first identifies an object of interest. (Step **310**). In one embodiment, for example, an administrator of the system **100** may select which object to analyze through a user interface, as discussed in further detail below. The operations analyzer **150** may also identify which CRUD operation to look for with respect to the identified object. In one embodiment, for example, administrator of the system **100** may select which CRUD operation to look for through a user interface, as discussed in further detail below. The operations analyzer **150** may evaluate only one of the CRUD operations, any subset of the CRUD operations or all of the CRUD operations simultaneously. To evaluate where the identified object is affected by the selected CRUD operations, the operations analyzer

150 may parse and trace through the database **130**. (Step **320** and **330**). The operations analyzer **150** may parse and trace through tenant common and system wide application data (e.g., pivot table **234** and universal data directory **236** in Step **320**) and tenant specific application data (e.g., tenant metadata **238**A-B in Step **330**). In one embodiment, for example, the tenant metadata may have backpointers to the objects they are applicable to. These "backpointers" can be a column on a table that defines the metadata, where the column stores the object type. In one embodiment, for example, the object type information may be represented directly in the code. When the code is saved to the system, the code is complied. While the code is being compiled, the code may be parsed to determine object types and store the object type information in a code table. The code table allows the object type to be queried without having to re-parse the code. The operations analyzer may then generate a report detailing how the object is affected by the CRUD operations. (Step **340**). As discussed above, the CRUD operations may include pre and post trigger validation rules, workflow rules and recursive save operations.

FIG. **4** illustrates an exemplary user interface **400** for an operations analyzer **150**. The user interface **400** includes an interface **410** for a user to select an object to perform the analysis thereon. The user interface **400** can also include an interface **420** for selecting a CRUD operation to analyze. As discussed above, any single CRUD operation or any combination of the CRUD operations may be selected to be analyzed. While the interfaces **410** and **420** illustrated in FIG. **4** are pull down menus, any other type of interface may be used. The user interface **400** may also include an interface **430** to initiate the operations analysis. Upon selection of the interface **430**, the operations analyzer **150** generates a report **440** as discussed herein. The report **440** may be generated within the user interface **400**, as illustrated in FIG. **4**, or may be generated at a separate location. For example, the report **440** may be generated and save in the database **130** for later analysis.

Generally speaking, the various functions and features of method **300** may be carried out with any sort of hardware, software and/or firmware logic that is stored and/or executed on any platform. Some or all of method **300** may be carried out, for example, by logic executing within system **100** in FIG. **1**. For example, various functions shown in FIG. **3** may be implemented using software or firmware logic that is stored in memory **106** and executed by processor **105** as part of application platform **110**. The particular hardware, software and/or firmware logic that implements any of the various functions shown in FIG. **3**, however, may vary from context to context, implementation to implementation, and embodiment to embodiment in accordance with the various features, structures and environments set forth herein. The particular means used to implement each of the various functions shown in FIG. **3**, then, could be any sort of processing structures that are capable of executing software and/or firmware logic in any format, and/or any sort of application-specific or general purpose hardware, including any sort of discrete and/or integrated circuitry.

The term "exemplary" is used herein to represent one example, instance or illustration that may have any number of alternates. Any implementation described herein as "exemplary" should not necessarily be construed as preferred or advantageous over other implementations.

Although several exemplary embodiments have been presented in the foregoing description, it should be appreciated that a vast number of alternate but equivalent variations exist, and the examples presented herein are not intended to limit the scope, applicability, or configuration of the invention in any way. To the contrary, various changes may be made in the function and arrangement of the various features described herein without departing from the scope of the claims and their legal equivalents.

What is claimed is:

1. A system for analyzing operations in a multi-tenant database system environment, comprising:

a database storing tenant application code, the tenant application code unique and accessible to only one of a plurality of tenants of the multi-tenant database system, and storing common application code, the common application code common and accessible to a plurality of tenants of the multi-tenant database system, the tenant application code and common application code both controlling a modification of an object in the multi-tenant database system environment; and

a processor to:

identify the object in the multi-tenant database system environment;

tracing through the tenant application code to identify therein every instance where system rules modify the object before and after the object is saved,

tracing through the common application code to identify therein every instance where tenant rules modify the object before and after the object is saved, and

generate a debugging report identifying every instance in the tenant application code and the common application code where the object is being modified.

2. The system of claim **1**, wherein the generated debugging report identifies a pre-trigger rule associated with the object.

3. The system of claim **2**, wherein the pre-trigger rule is one of a customer written validation rule and a system validation rule which validates a data field associated with the object before the object is saved.

4. The system of claim **1**, wherein the generated debugging report identifies a post-trigger rule associated with the object.

5. The system of claim **4**, wherein the post-trigger rule is one of an assignment rule, a workflow rule and an escalation rule which causes an action after the object is saved.

6. The system of claim **5**, wherein the action is an update to the object.

7. The system of claim **5**, wherein the action is creation, read, update, deletion or undeletion of a second object.

8. The system of claim **1**, wherein the generated debugging report identifies a recursive save of the object.

9. The system of claim **1**, wherein the modification is one of a creation, read, update, deletion or undeletion operation on the object.

10. A method for analyzing operations in a multi-tenant database system environment by a processor, comprising:

identifying, by the processor, an object in the multi-tenant database system environment;

tracing through, by the processor, common application code, the common application code accessible to a plurality of tenants of the multi-tenant database system, to identify therein every instance where system rules modify the object before and after the object is saved;

tracing through, by the processor, tenant application code, the tenant application code unique and accessible to only one specific tenant of the multi-tenant database system, to identify therein every instance where tenant rules modify the object before and after the object is saved; and

generating, by the processor, a debugging report identifying every instance in the common application code and tenant application code where the object is being modified.

11. The method of claim 10, further comprising identifying a pre-trigger rule which validates a data field associated with the object before the object is saved.

12. The method of claim 11, further comprising identifying a post-trigger rule which causes an action after the object is saved.

13. The method of claim 12, wherein the action is an update to the object.

14. The method of claim 12, wherein the action is creation, read, update, deletion or undeletion of a second object.

15. The method of claim 12, further comprising determining a processing time associated with each pre-trigger rule and post trigger rule,

wherein the generating a report further comprises reporting the determined processing time associated with each pre-trigger rule and post trigger rule.

16. The method of claim 10, further comprising identifying a recursive save of the object.

17. The method of claim 10, further comprising parsing the respective application code to identify to identify system and tenant rules which affect the object before and after the object is saved.

18. A user interface for visualizing create, read, update, delete and undelete ("CRUD") operations affecting an object in a multi-tenant database system environment, comprising:

a display, comprising:

an interface for selecting an object;

an interface for causing the generation of a debugging report identifying each instance in tenant application code unique and accessible to only one of a plurality of tenants of the multi-tenant database where system rules modify the object before and after the object is saved and for identifying each instance in common application code common and accessible to a plurality of tenants of the multi-tenant database system where system rules modify the object before and after the object is saved by tracing through both the tenant application code and common application code.

19. The user interface of claim 18, wherein the report provides a link to tenant specific code or tenant common code where the selected object is affected by the selected CRUD operation.

20. The user interface of claim 18, wherein the user interface is presented to an administrator of the multi-tenant database system.

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